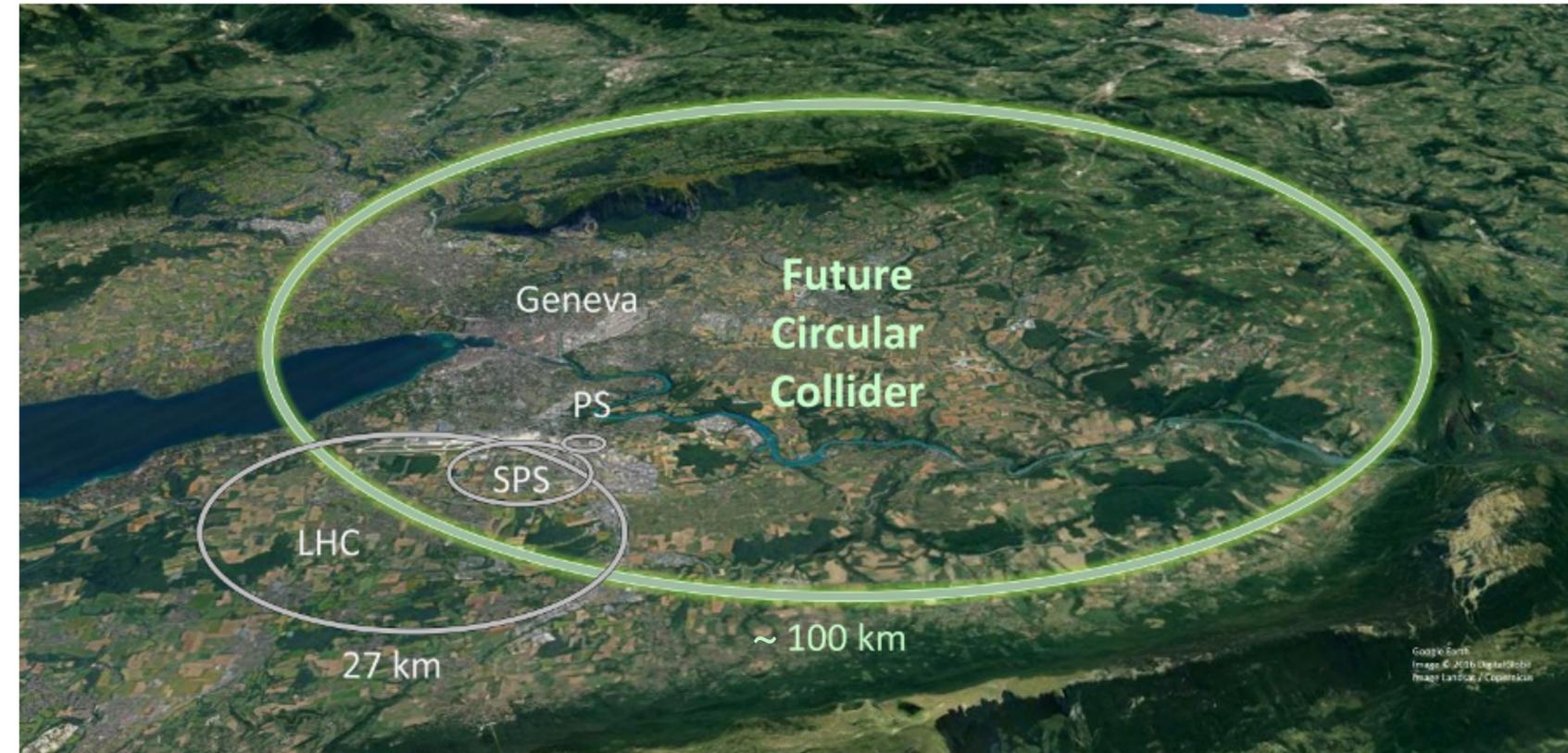


# Tera-Z with FCC-ee : a b/c/ $\tau$ physics factory for our future J.Hirschauser & S.Eno

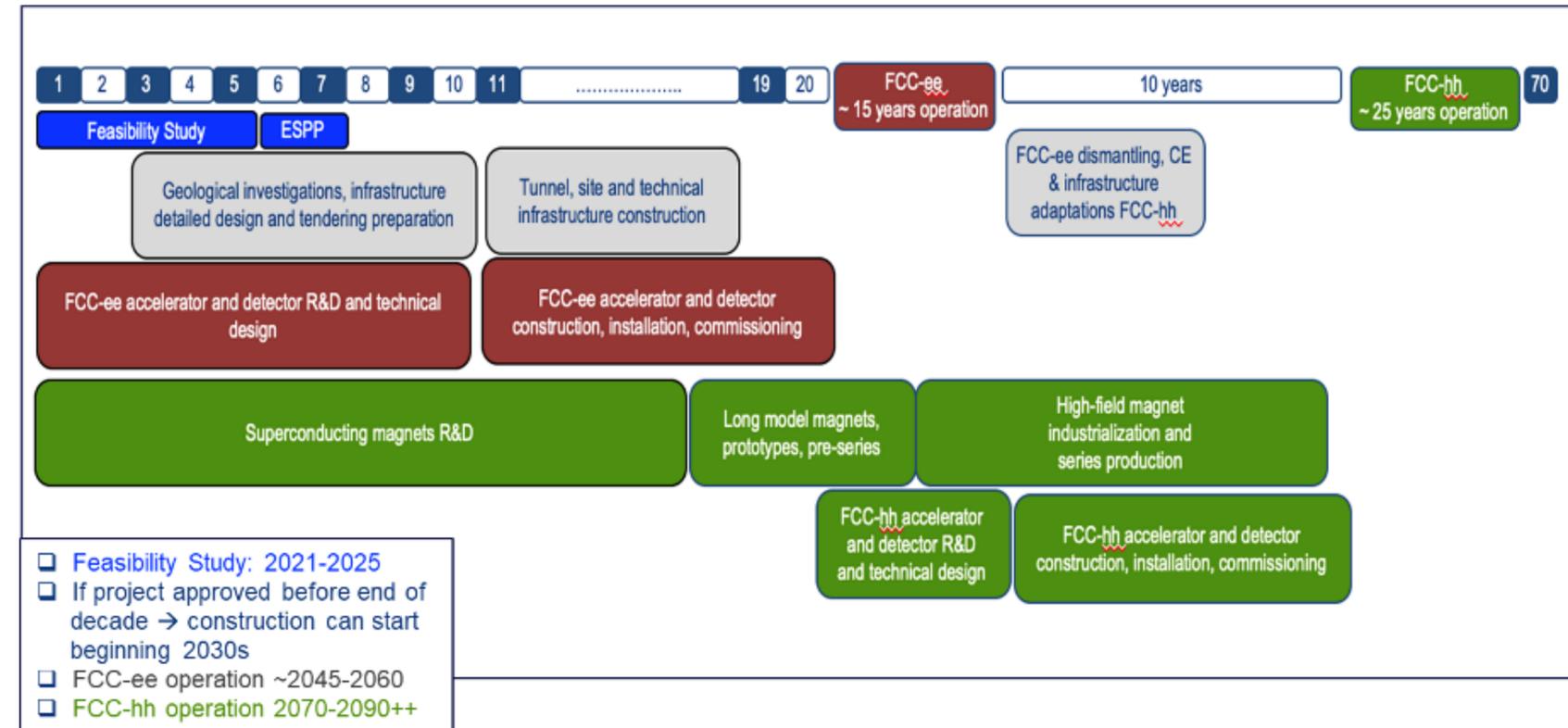
- Tera-Z program will produce  $2 \times 10^{12}$  Z bosons per IP
  - $L \sim 180 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  on Z resonance
  - $87 \text{ ab}^{-1}$  per year per IP
- $Z \rightarrow \text{bb/cc}/\tau\tau$  : unprecedented laboratory for flavor physics
  - b quark ID feasible with lifetime measurements for bs with  $E \sim m_Z/2$
  - All flavors of b mesons and baryons can be produced
- **Natural extension of inspiring physics programs at LHCb + Belle II:**
  - Realize new measurements not feasible at LHCb + Belle and
  - Confront most interesting results with  $10\times$  more events and next generation detectors



Particle production ( $10^9$ )	$B^0 / \bar{B}^0$	$B^+ / B^-$	$B_s^0 / \bar{B}_s^0$	$\Lambda_b / \bar{\Lambda}_b$	$c\bar{c}$	$\tau^- / \tau^+$
Belle II	27.5	27.5	n/a	n/a	65	45
FCC-ee	300	300	80	80	600	150

- **Combine best attributes** of LHCb and Belle:

Attribute	$\Upsilon(4S)$	$pp$	$Z^0$
All hadron species		✓	✓
High boost		✓	✓
Enormous production cross-section		✓	
Negligible trigger losses	✓		✓
Low backgrounds	✓		✓
Initial energy constraint	✓		(✓)



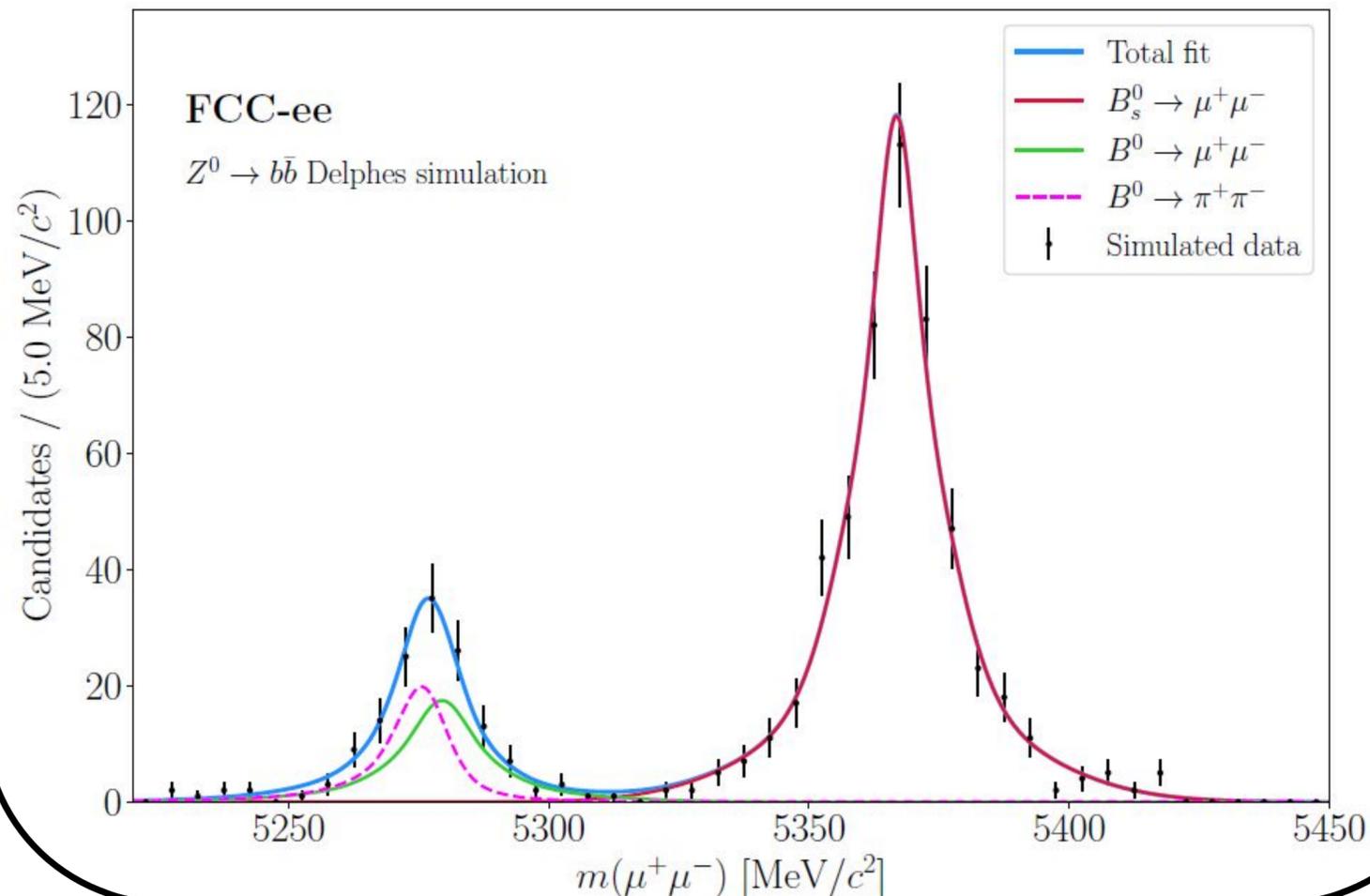
# Some examples of b/c/τ physics reach at Tera-Z

Rare (semi-)leptonic b-hadron decays are powerful probes of potential flavor dynamics beyond the SM

Tera-Z + **next generation detectors** = unique sensitivity to rare decays with 3rd generation fermion couplings

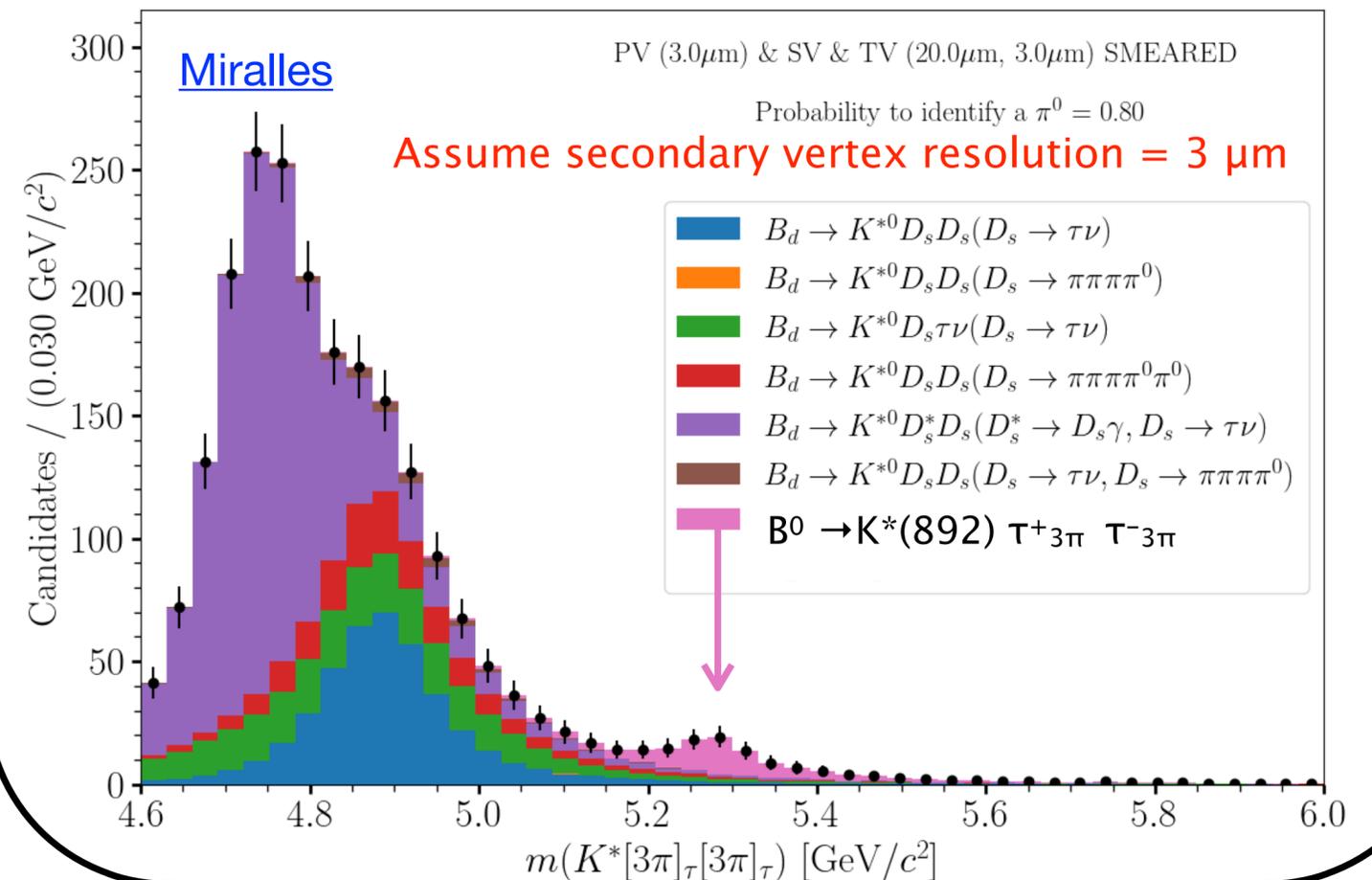
## Precise measurement of $B \rightarrow \mu^+ \mu^-$

- **Tracking resolution** → separation from  $B_s \rightarrow \mu^+ \mu^-$
- **Particle ID** → suppress  $B^0 \rightarrow \pi^+ \pi^-$
- **Flavor tagging** → potential to measure CP asymmetries in  $B_s \rightarrow \mu^+ \mu^-$



## Measurement of $b \rightarrow s \tau^+ \tau^-$

- $b \rightarrow s \ell^+ \ell^-$  are critical probes of lepton universality
- 3rd generation could be especially important
  - SM prediction :  $\text{BR}(B^0 \rightarrow K^* \tau^+ \tau^-) \sim 10^{-7}$
  - Belle II expected :  $\text{BR}(B^0 \rightarrow K^* \tau^+ \tau^-) < 10^{-5}$  [arXiv:1705.11106](https://arxiv.org/abs/1705.11106)



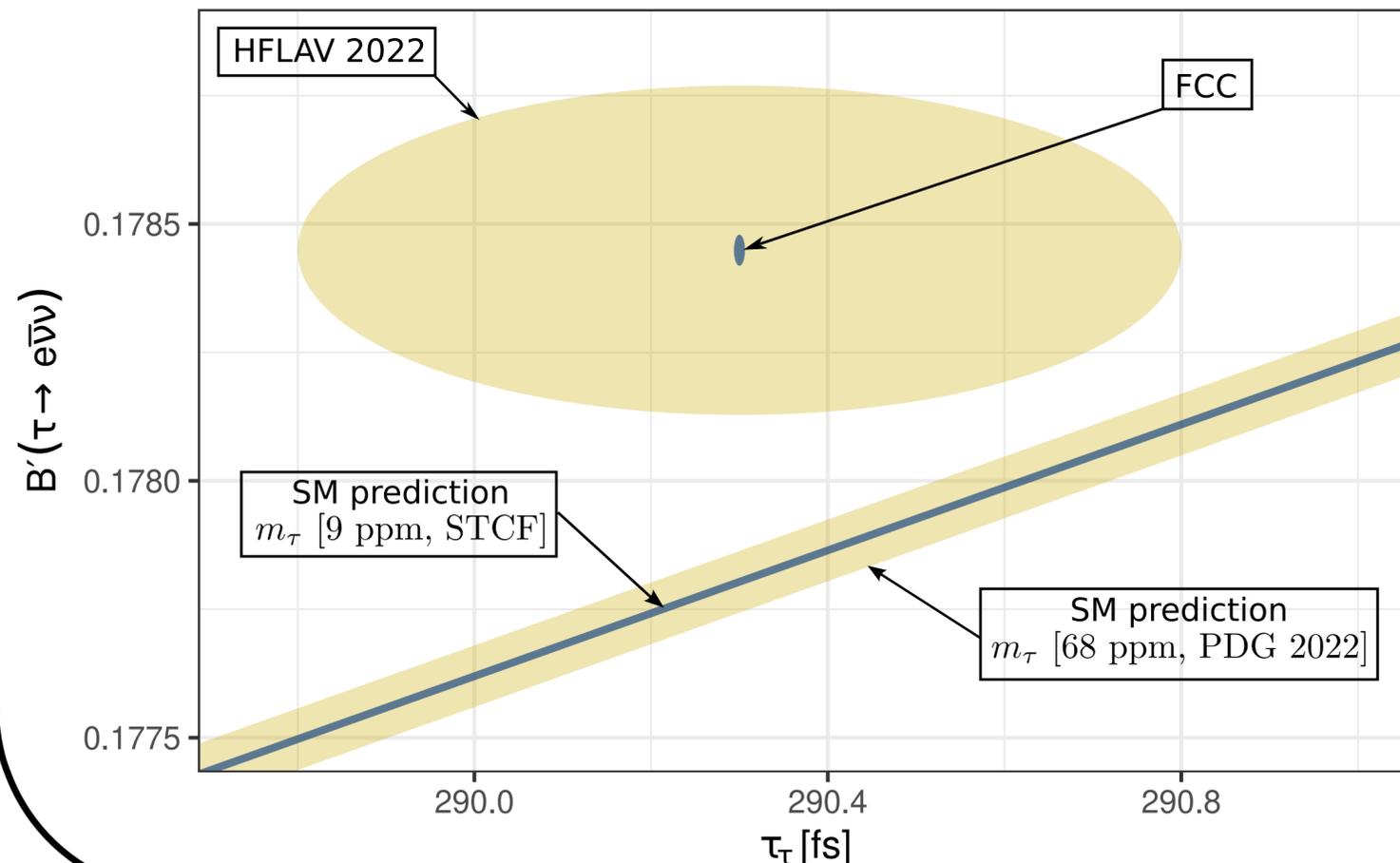
# More examples of b/c/ $\tau$ physics reach at Tera-Z

Clean environment, state-of-the-art detectors, and immense datasets allow precise studies with tau leptons

Many more examples in FCC Snowmass Summary : <https://arxiv.org/pdf/2203.06520.pdf>

## Test lepton universality in $\tau$ decays

- Precise  $\tau$  measurements provide test of lepton universality
  - lifetime measurements with  $10^{-4}$  precision (0.04 fs)
  - leptonic BF measurements with  $2 \times 10^{-4}$  precision
- Excellent detectors required for tau reconstruction



## Measurement of $B_C^+ \rightarrow \tau^+ \nu$

[arXiv:2105.13330](https://arxiv.org/abs/2105.13330)

- Theoretically clean and independent probe of  $b \rightarrow c \tau^+ \nu$  coupling present in anomalous  $B \rightarrow D^{(*)} \tau^+ \nu$  results
- $B_C \rightarrow \tau \nu$  inaccessible at b-factories and very challenging at hadron colliders

